

COMPARISON OF OBSERVED AND COMPUTED
SETTLEMENTS OF STRUCTURES
IN CHICAGO

BY

MEHMET ENSAR UYANIK

B.S., University of Illinois, 1942

M.S., University of Illinois, 1943

AN ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN
ENGINEERING IN THE GRADUATE SCHOOL OF
THE UNIVERSITY OF ILLINOIS, 1945

URBANA, ILLINOIS

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ABSTRACT

1. PROBLEM:

Soil mechanics has provided a method for computing the settlements of buildings due to the compression of underlying soft clay deposits. Since the method involves several assumptions concerning the behavior of undisturbed masses of clay, its reliability can be investigated only by comparing the computed and observed settlements of actual structures under a wide variety of conditions.

Previous investigations have shown that settlement computations can be relied upon, provided the compressible soil consists of fairly thin layers which are largely prevented from lateral bulging by the friction and adhesion along their upper and lower boundaries. No comparisons have been available, however, to determine the reliability of similar computations if the compressible clay is very thick and is located close to the footings, so that extensive lateral deformation might conceivably occur. If the deformation were large, the observed settlements might greatly exceed the computed settlements.

Soil conditions in Chicago approximate the latter conditions. Furthermore, they have been extensively explored by means of the techniques of soil mechanics, so that the values of the soil constants required for settlement computation are known. Finally, fairly complete settlement records of actual buildings are available. Hence, all of the information exists for a study of the relation between observed and computed settlements of structures above a deposit which consists of thick beds of compressible clay. This thesis represents such a study. It also includes the development of a simplified procedure for estimating the settlement of structures in the Chicago Loop area.

2. PROCEDURE FOLLOWED:

Seven buildings in or near the Loop area in Chicago were chosen for settlement computation. All the information about these buildings was made available by the Joint Committee on Soil Mechanics and Foundations, a committee formed under the auspices of the Western Society of Engineers, the Illinois Section of the American Society of Civil Engineers, and the Engineering Experiment Station of the University of Illinois.

The boring logs made for the Chicago Subway project contain a record of the natural water content of the clay. At least one such log was available near the site of each of the seven buildings. The clay deposit under each building was divided into layers with constant water content, and the soil constants necessary for settlement computation were obtained by means of statistical relations between such constants and the water content.

Furthermore, stresses at different depths under each of several chosen points of every building were computed by the theory of elasticity. The stress variation with depth under each point was plotted and the stress at mid-height of each layer was considered as the average stress within the layer.

With a knowledge of the stresses and soil constants, the settlements contributed by each layer were computed. The settlements produced by each layer under a given point were summed up to determine the computed settlement of that point. Computed settlement contours or profiles along different sections of the building were drawn. These contours and profiles of computed settlement were compared with actual settlement contours and profiles. Since the computed settlement did not include the so-called secondary time effect, this portion of the total settlement was deducted, by means of a graphical procedure, from the observed settlements before the comparisons were made.

3. SIMPLIFIED PROCEDURE:

In order to supply the designing engineer with necessary information about the approximate magnitude of the possible settlement of a building, a simple, approximate method of computing settlement was developed. The method was based upon theory and modified empirically. The water content of the clay under the Loop area was assumed to vary within two reasonable limits. Furthermore, a layer of clay with constant water content, within the assumed limits, was taken to be the only source of settlement, and the stress along any vertical line in the layer was assumed equal to that at mid-height. The thickness of the layer was determined by trial and error to satisfy the condition that the settlements computed by the simplified procedure should agree most closely with those determined by the general method. A layer of clay with a thickness of 34.0 ft. and a water content varying from 22.0 to 36.0 percent was found to satisfy the above requirements fairly well. A straight line was found to represent quite accurately the relation between settlement and stress. The equation of the line is

$$s = 0.20 + 1.34 p$$

where p is the stress at Elev. -20.00 , Chicago City Datum, in tons per square foot, and s is the settlement in feet.

The straight line was modified empirically to represent the relation between the observed settlement and the stress at Elev. -20.0 . The equation of this line is

$$s = 0.20 + 1.40 p$$

This equation differs slightly from the previous equation and it represents the actual settlements quite accurately. Hence the only information needed to find the approximate magnitude of the settlement of a point in a building located in the Loop area of Chicago is the stress at Elev. -20.0 under that point.

4. CONCLUSION:

The average settlement for all the buildings computed by the general method was found to be 80 percent of the average actual settlement. Hence, it can be concluded that the errors introduced by the various assumptions are relatively unimportant and that

the customary method of computing settlements is sufficiently reliable even for subsoil conditions in Chicago, where the compressible layers are thick and near the surface.

In addition, the results indicate that the pattern of the differential settlement can be reliably predicted provided the structure is not exceptionally rigid, and quite accurately predicted if the structure is flexible. The factor which appears to limit the accuracy is the variability of the physical properties of the subsoil from point to point at a given level below the structure.

The semi-empirical procedure suggested for estimating settlements affords a rapid and reliable method for predicting the settlement of a building in Chicago located above at least 25 feet of soft clay.

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